The LHCb software track trigger

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HL-LHC workshop, CERN

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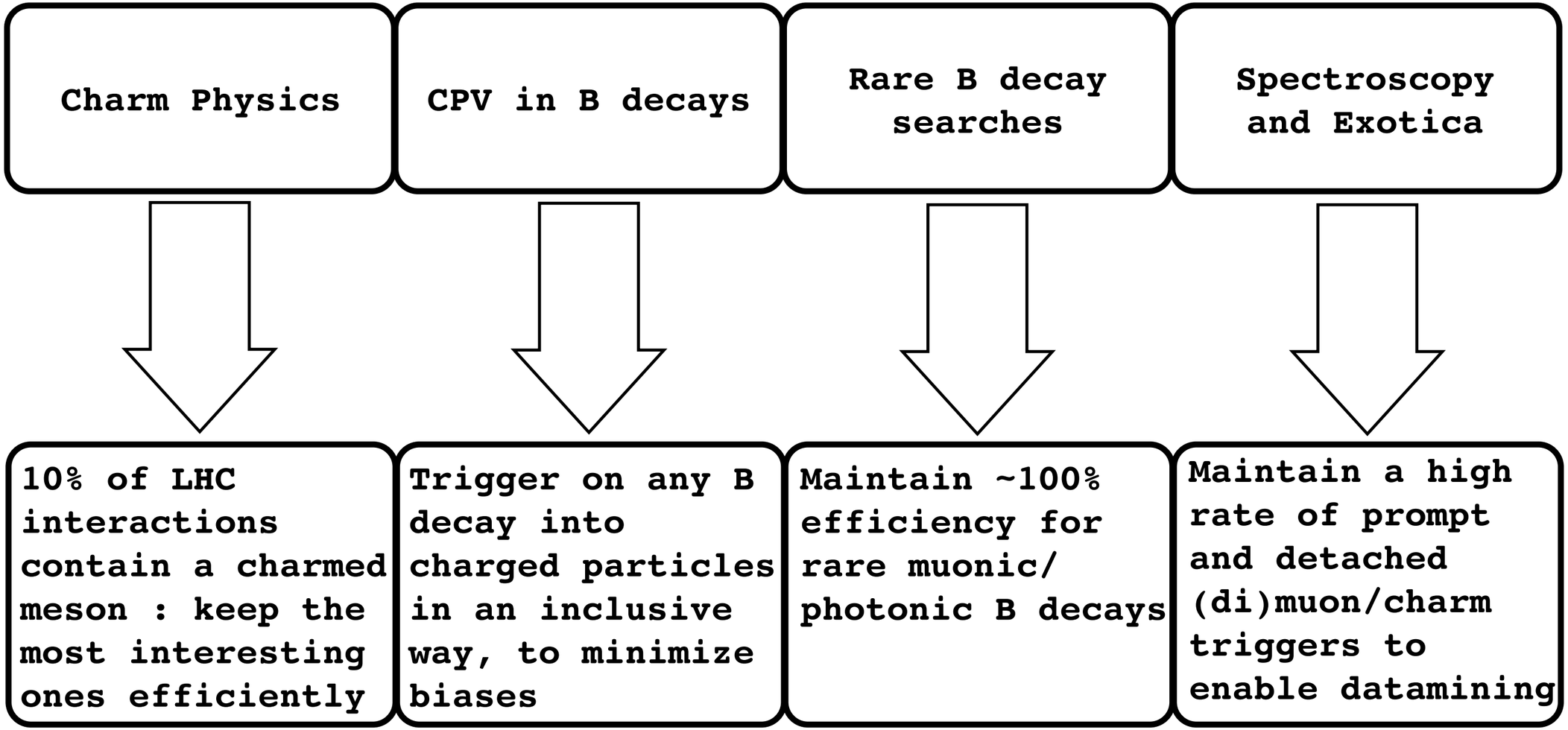
Overview of talk

I will briefly describe our 1Track trigger with emphasis on how the performance could be expected to evolve from Run I to the HL-LHC era

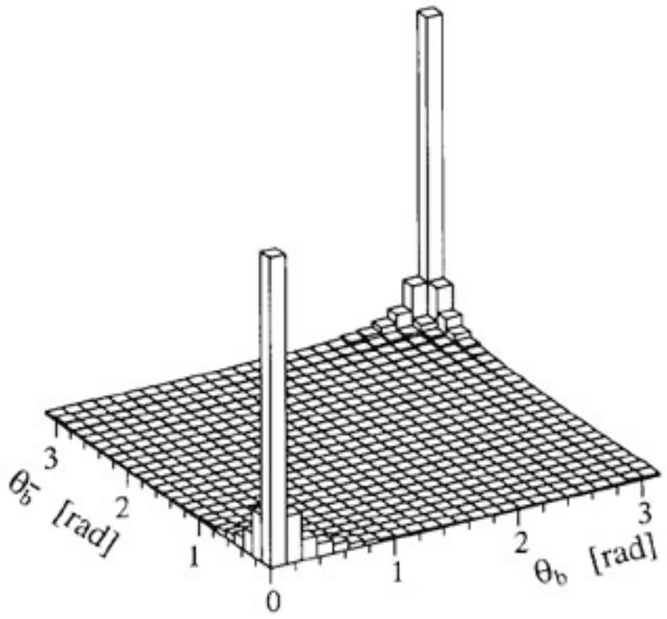
Obviously the LHCb track trigger selects very different physics to the GPD track triggers. Hopefully this means the talk is interesting rather than irrelevant...

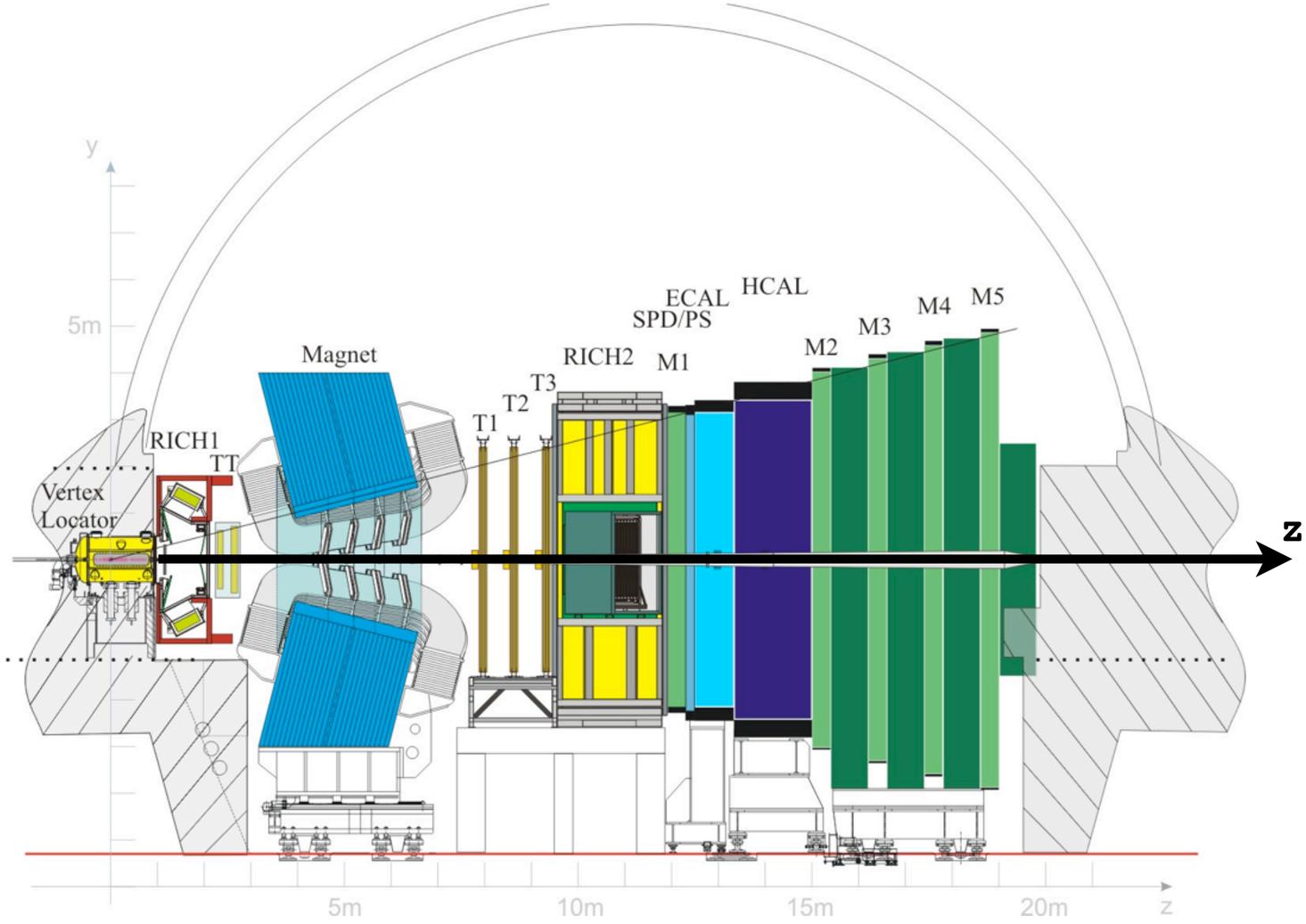
What do we want to trigger on?



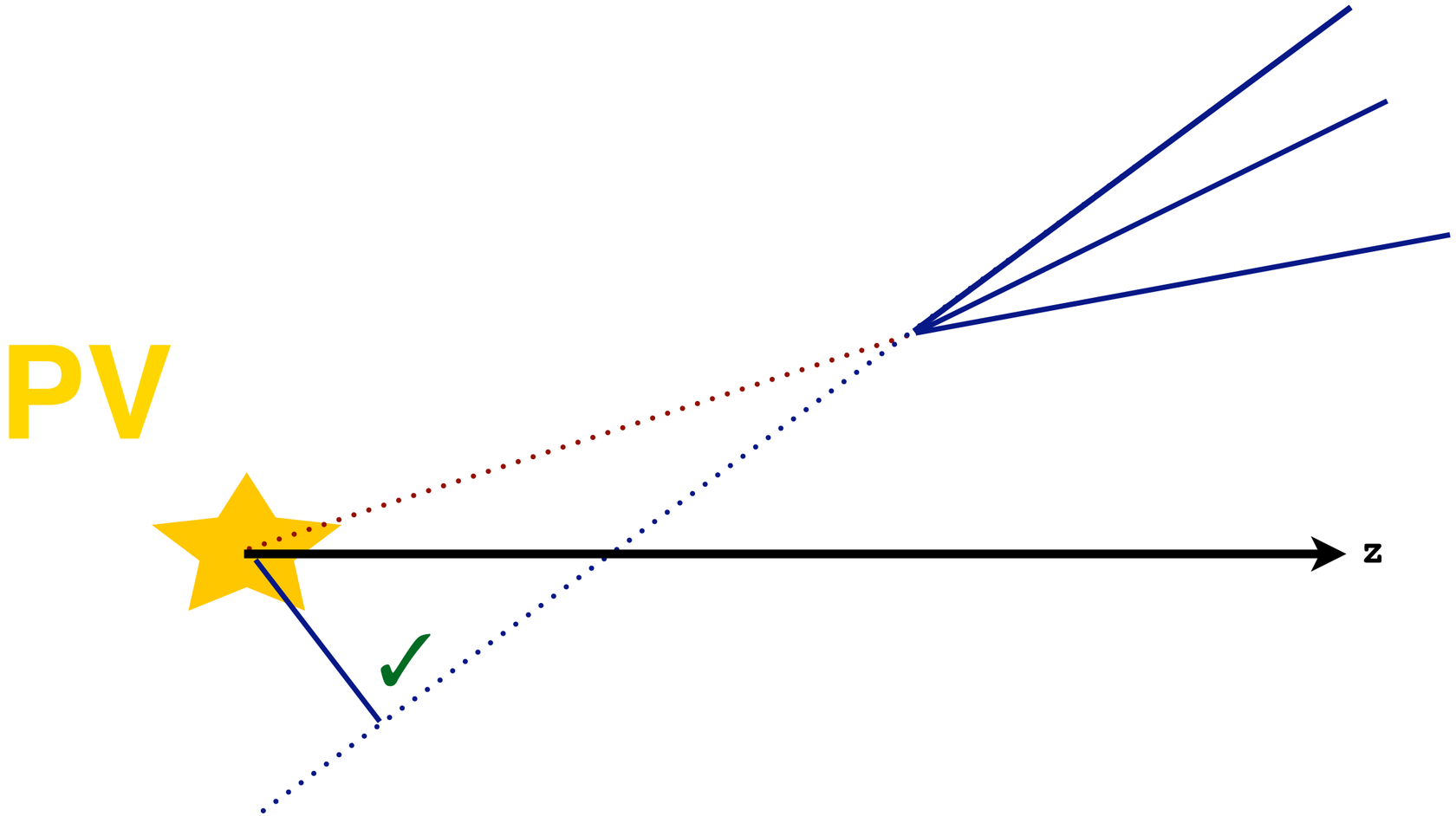
Note : not the entire physics programme, see the "implications of LHCb measurements" for more

The LHCb detector





How do you select b/c decays?



A B has average momentum of 100 GeV and mass of 5+ GeV

One of the daughters must have high momentum and P_T

A B flies a long way

One of the daughters must have high impact parameter

1Track reconstruction in Run I

LHCb-PUB-2011-003

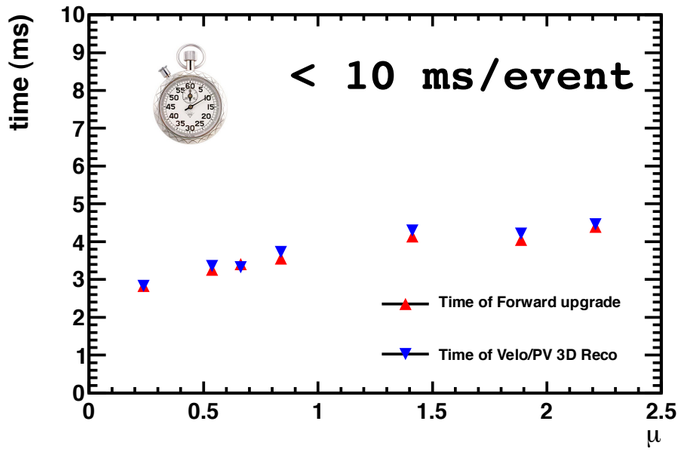
1. Full reconstruction of tracks in vertex locator

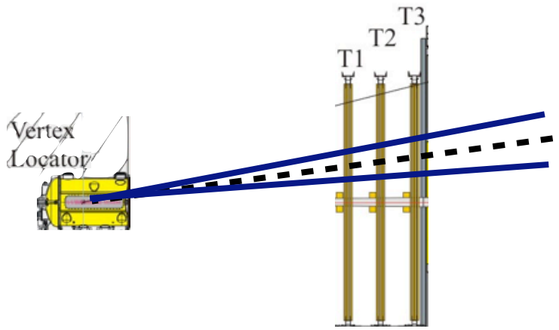
⇓

Select displaced tracks

⇓

2. Reconstruction of displaced tracks in regions of interest





Region of interest defined by assumed track P/P_T, 3/1.6 GeV in 2012

1Track reconstruction in Run I, muons

LHCb-PUB-2011-003

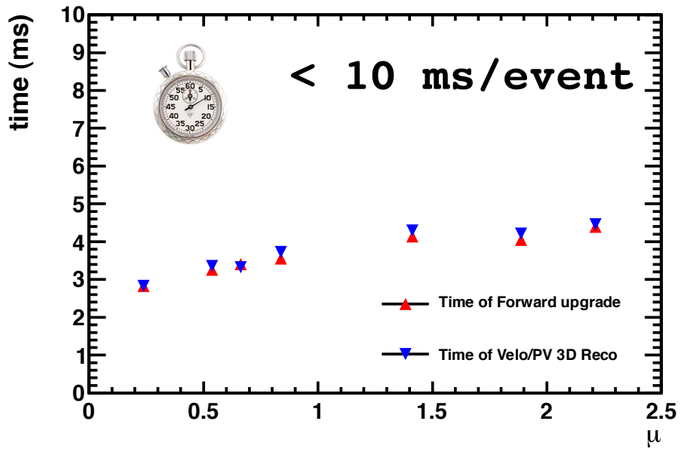
1. Full reconstruction of tracks in vertex locator

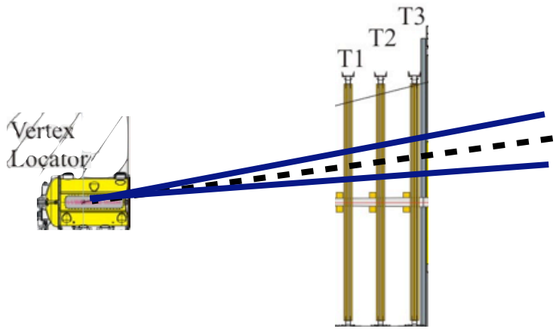
⇓

2. Match VELO tracks to muon hits

⇓

Reconstruction of muon-matched tracks in regions of interest

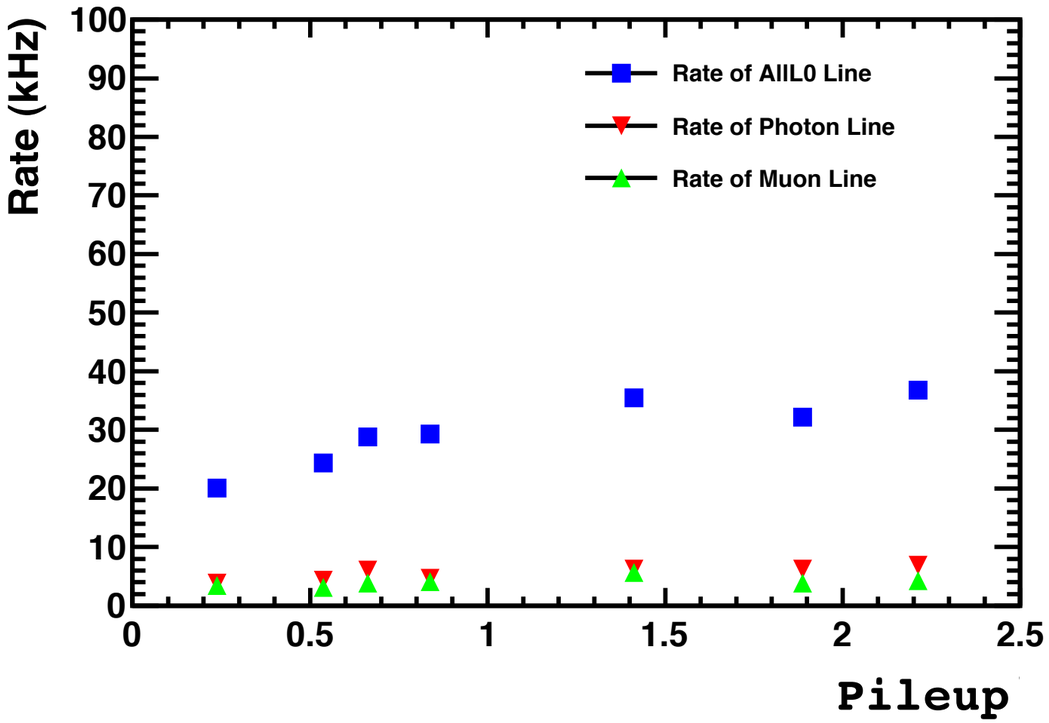


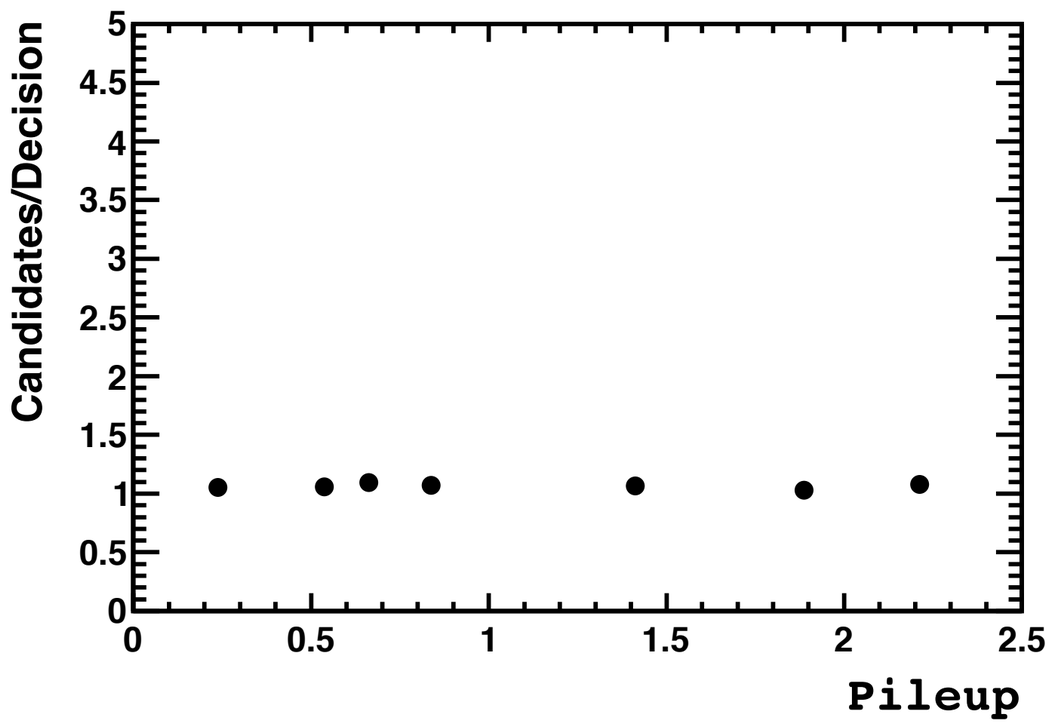


Muon-matching kills as more tracks than the IP cut, can afford softer P/P_T cuts, 3/0.5 GeV in 2012

Single track triggering and pileup

LHCb-PUB-2011-003



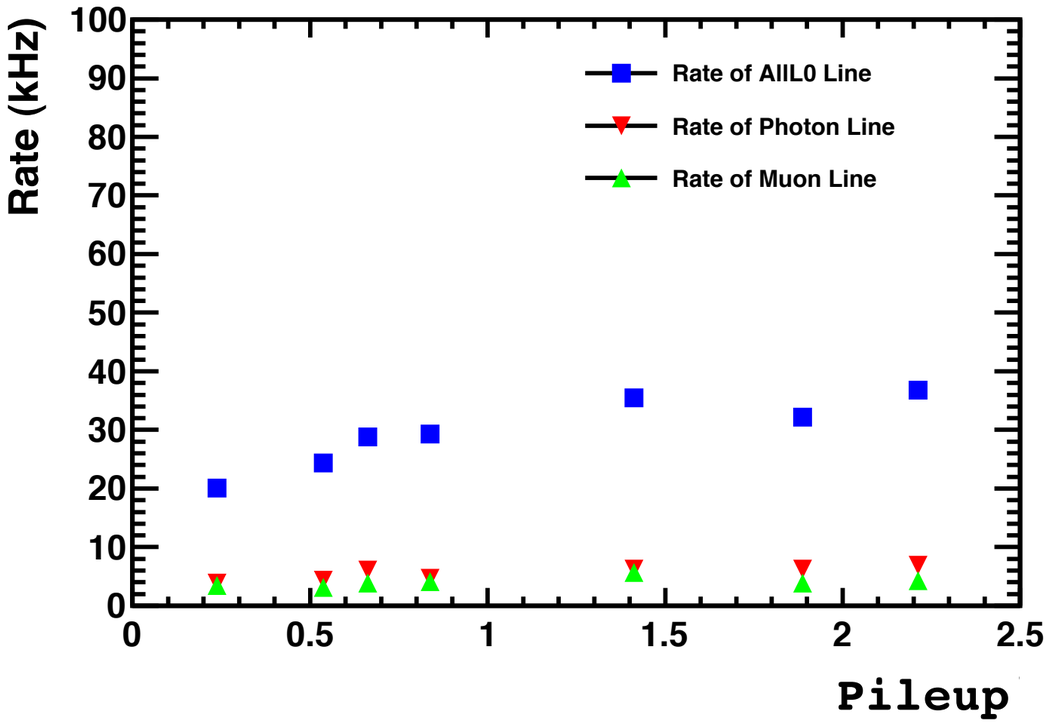


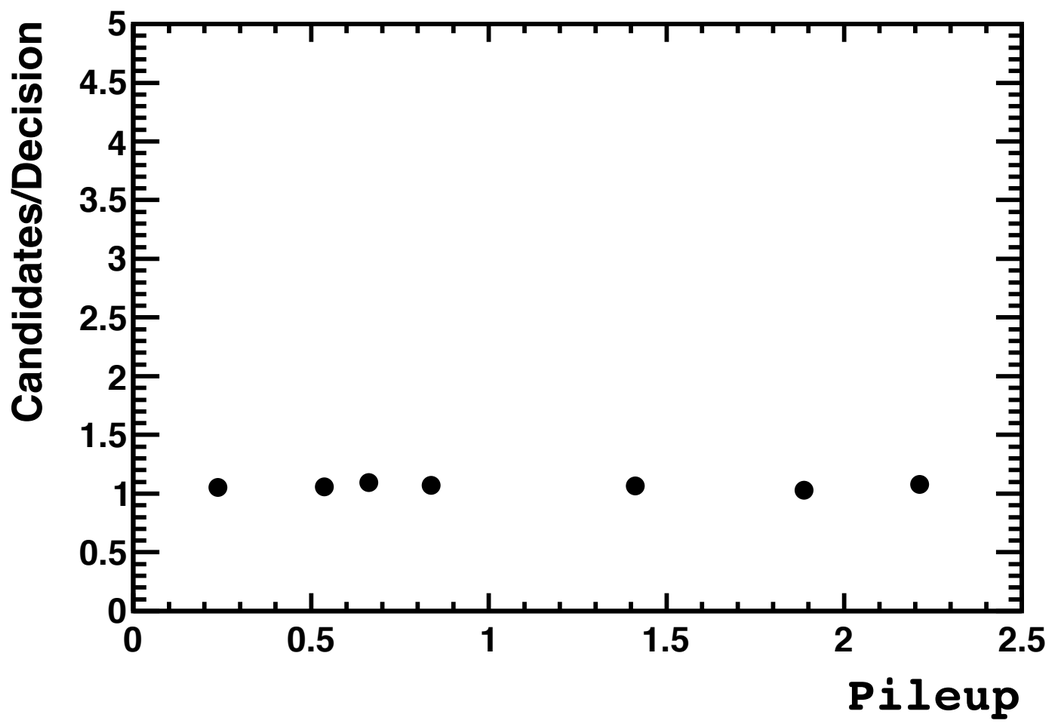
Triggering on a single track makes you basically insensitive* to increasing combinatorics, since there is nothing to combine!

See LHCb-PUB-2011-003

Single track triggering and pileup

LHCb-PUB-2011-003





*note that this assumes that the cross-section of interesting processes is a small fraction of the total. More on this later.

See LHCb-PUB-2011-003

Signal performance in Run I

ArXiv:1310.8544

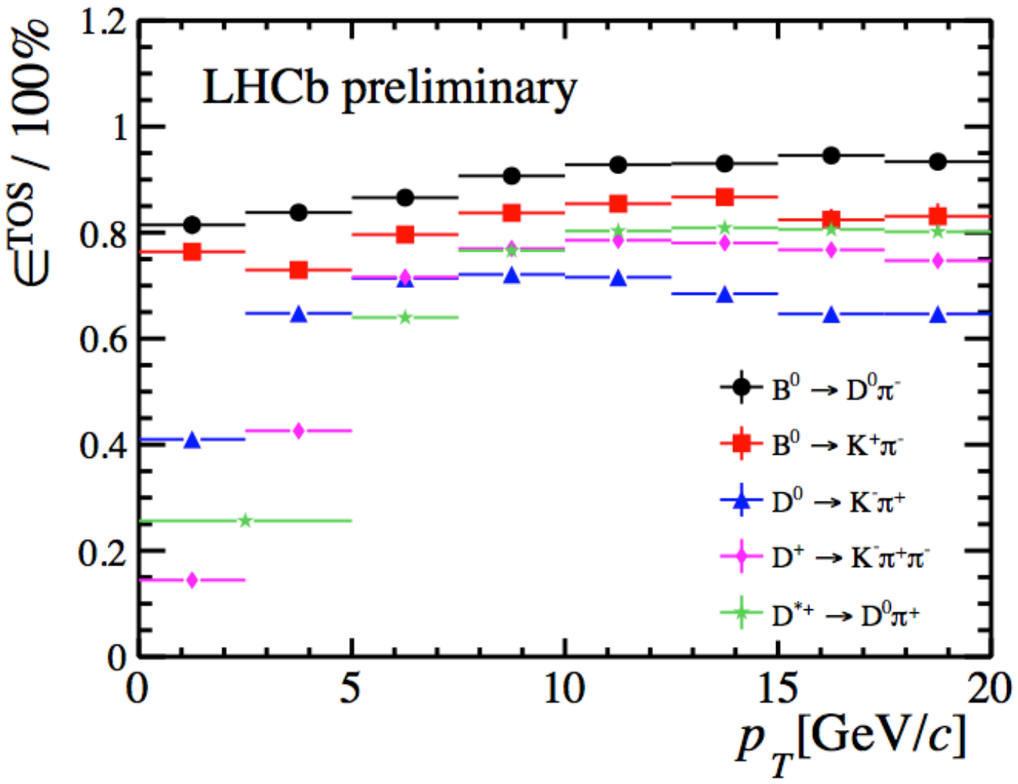


Figure 3. `Hlt1TrackAllL0` performance: TOS efficiency for various channels as a function of B or D p_T.

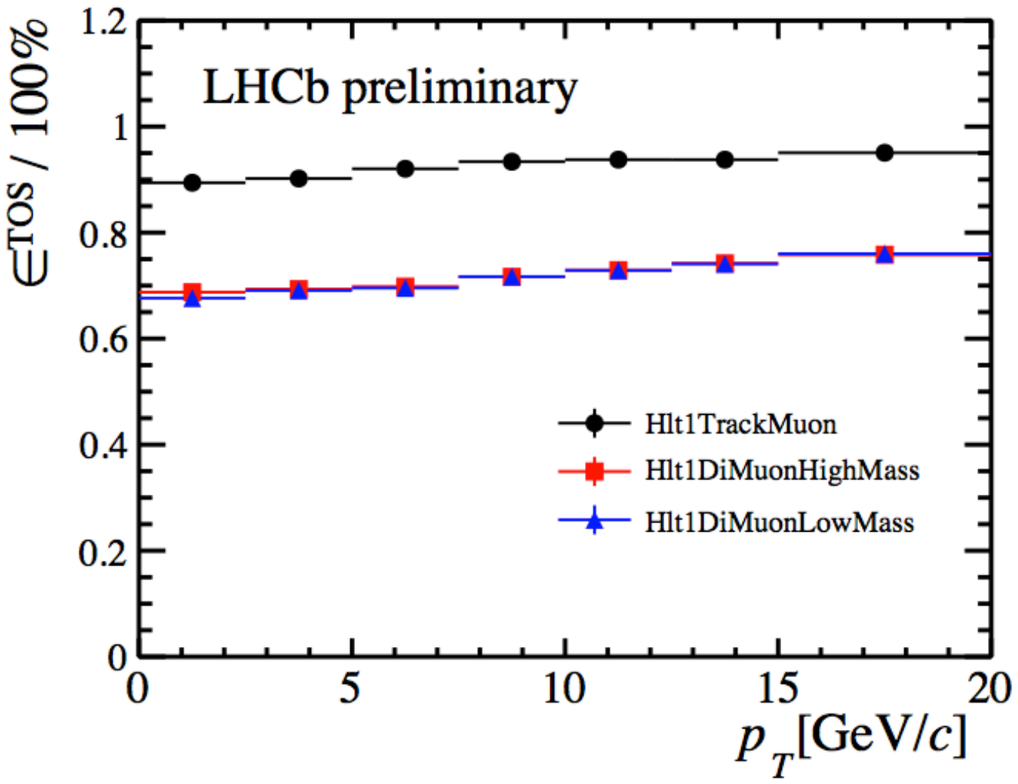


Figure 4. HLT1 muon trigger performance: TOS efficiency for $B^+ \to J/\psi K^+$ candidates as function of B^+ p_T.

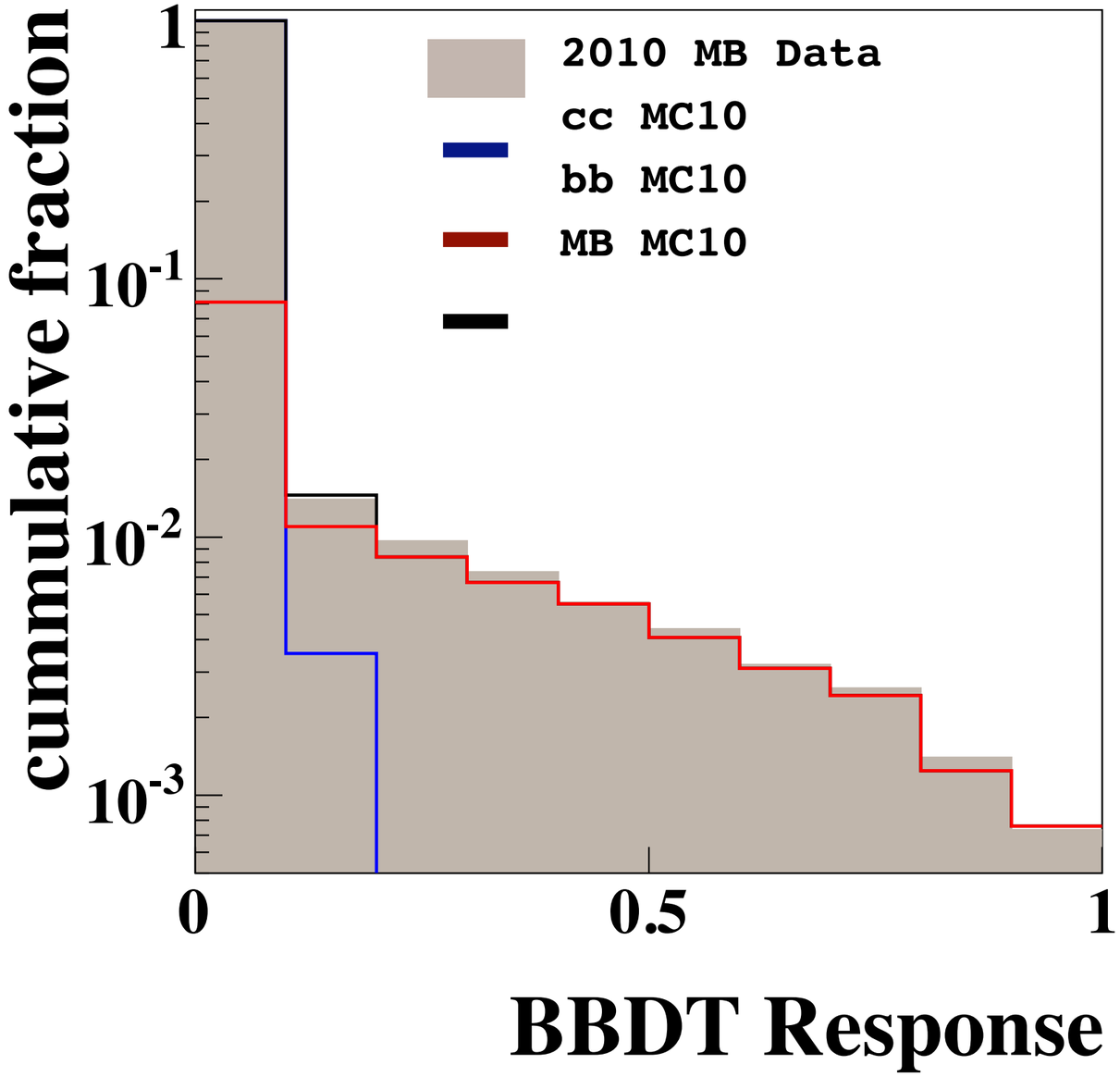
A brief comment on topologies

Once you have the single track, you can discriminate against ccbar events by building a seed around it

Use the missing-momentum corrected B mass to discriminate with ~100% purity against charm even in the case where you only partially reconstruct the B.

Evaluated as a safety option for the upgrade : doing combinatorics in an ROI around the seed takes ~zero time.

Using a BDT classifier gains x3 in rate compared to cut-based alternative.



See also LHCb public notes and trigger publications
LHCb-PUB-2011-002,003,016
http://arxiv.org/abs/1310.8544
http://arxiv.org/abs/1211.3055

Gligorov&Williams http://arxiv.org/abs/1210.6861

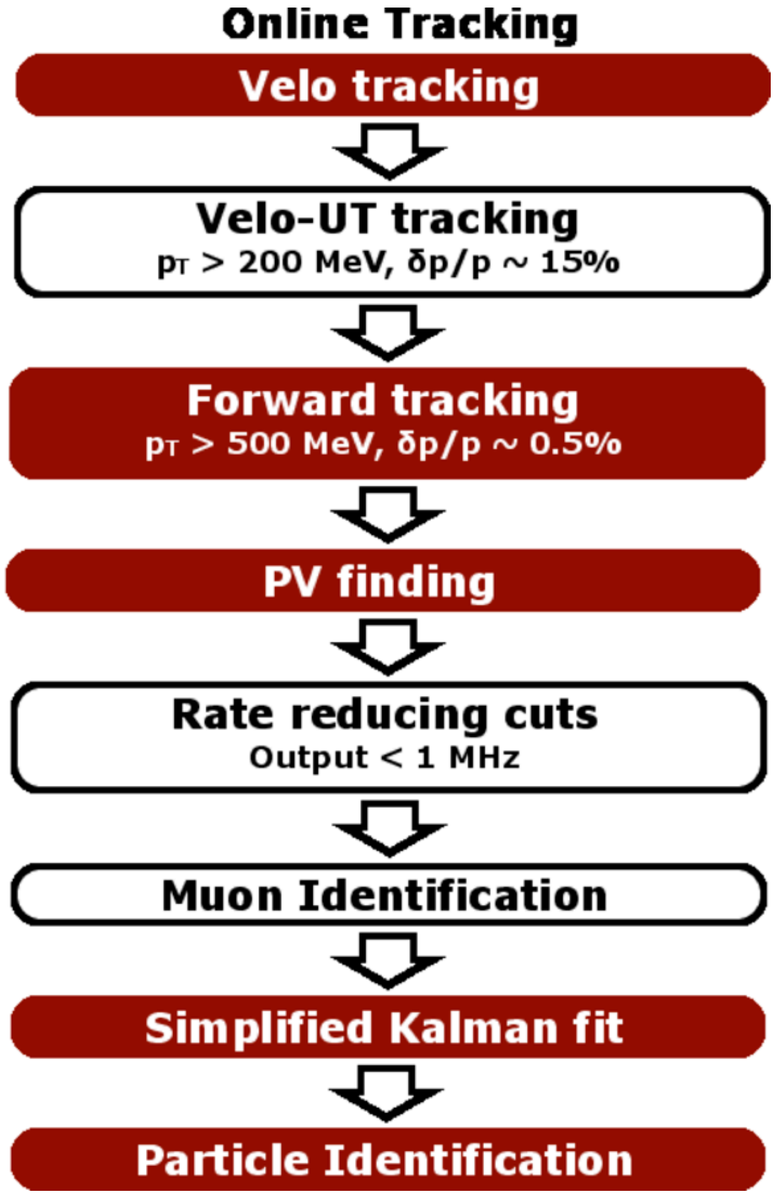
OK, so what about HL-LHC?

Reconstruction sequence in HL-LHC

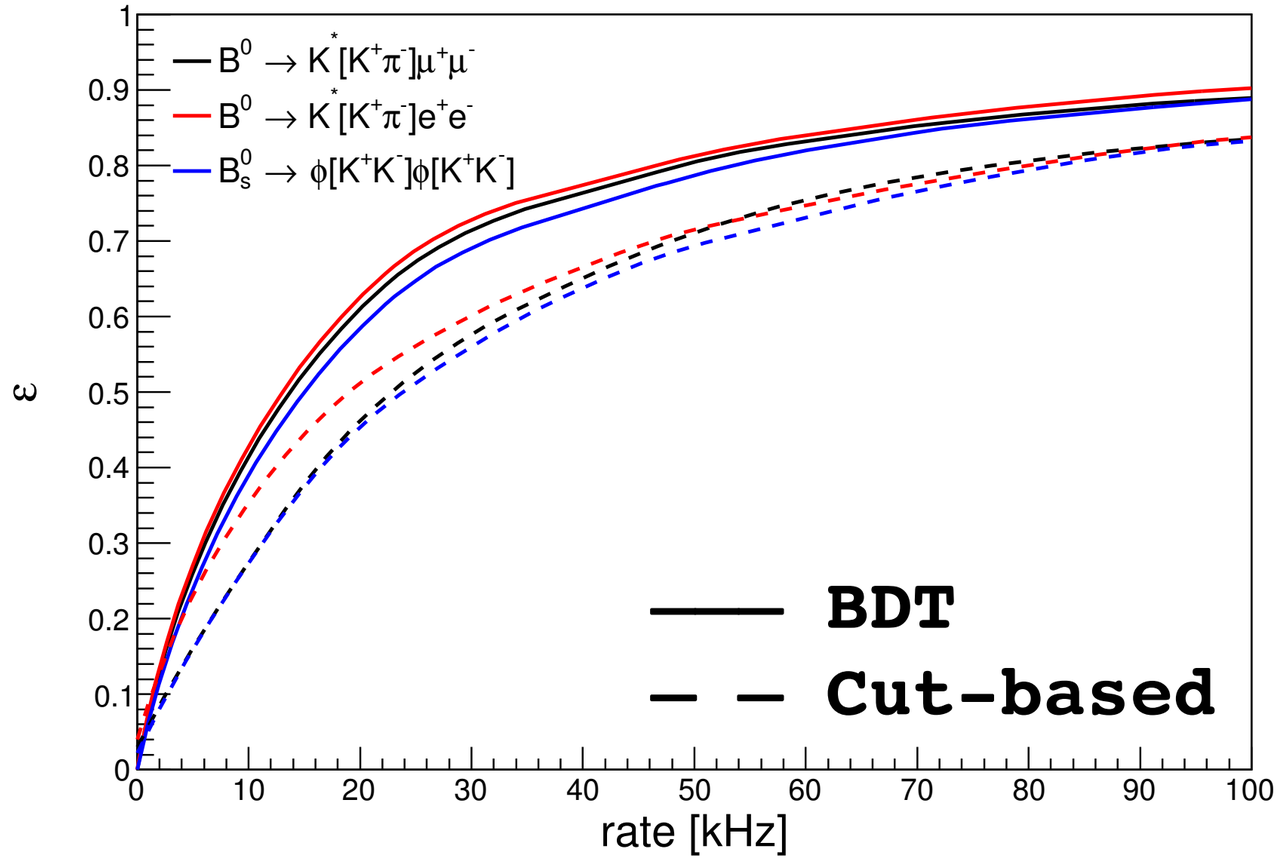
Compared to Run I, we will have all tracks above 500 MeV of P_T upfront, regardless of displacement.

Track quality available after some initial rate reduction.

Can think about moving to a BDT based track trigger?



BDT track trigger, Run II gains?

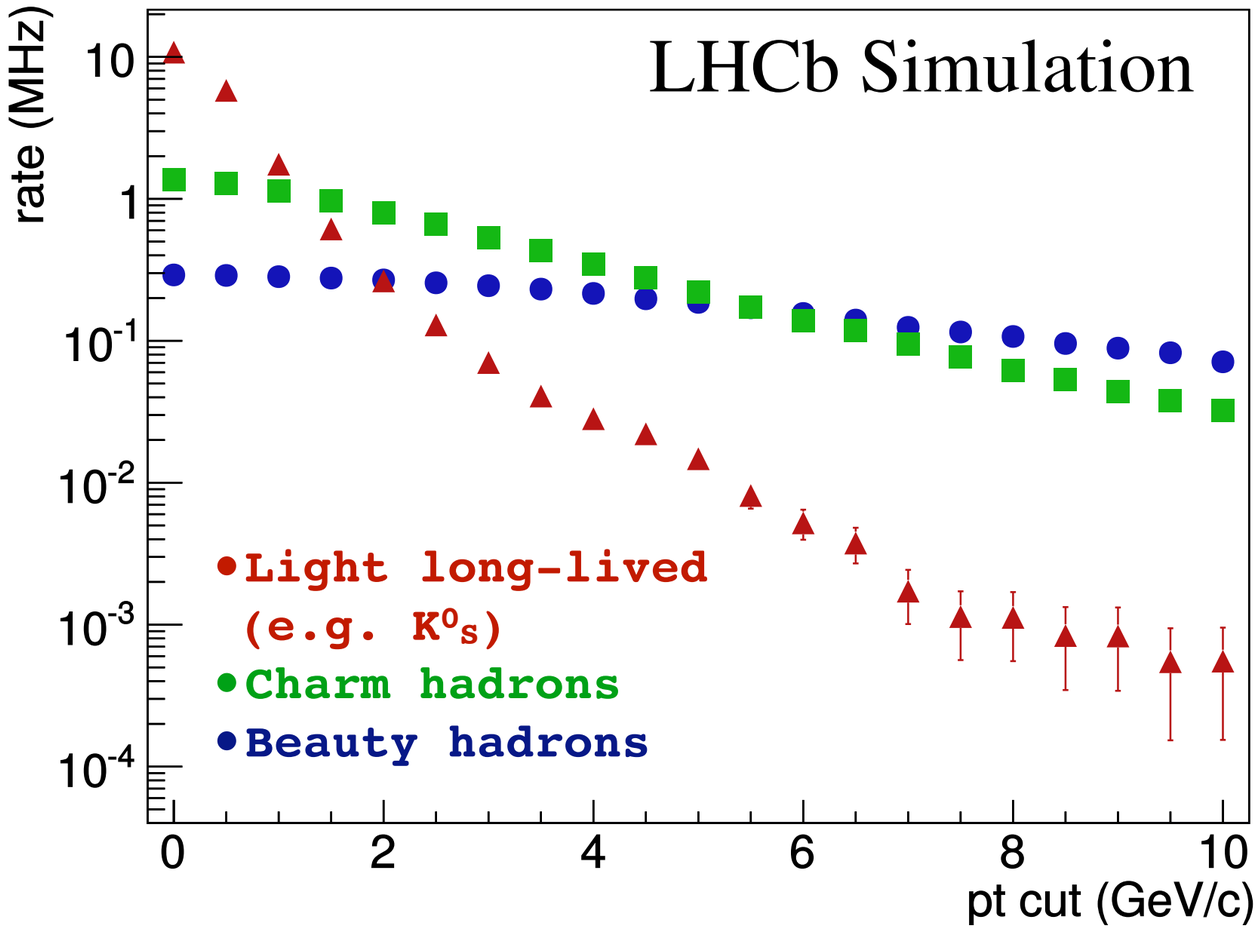


BDT => better performance is not new, we see this everywhere. The point is that the event reconstruction makes this possible.

Can use track "primitives" like number of hits in various subdetectors to discriminate against fakes before track fit.

Track trigger @ HL-LHC

LHCb-PUB-2014-027

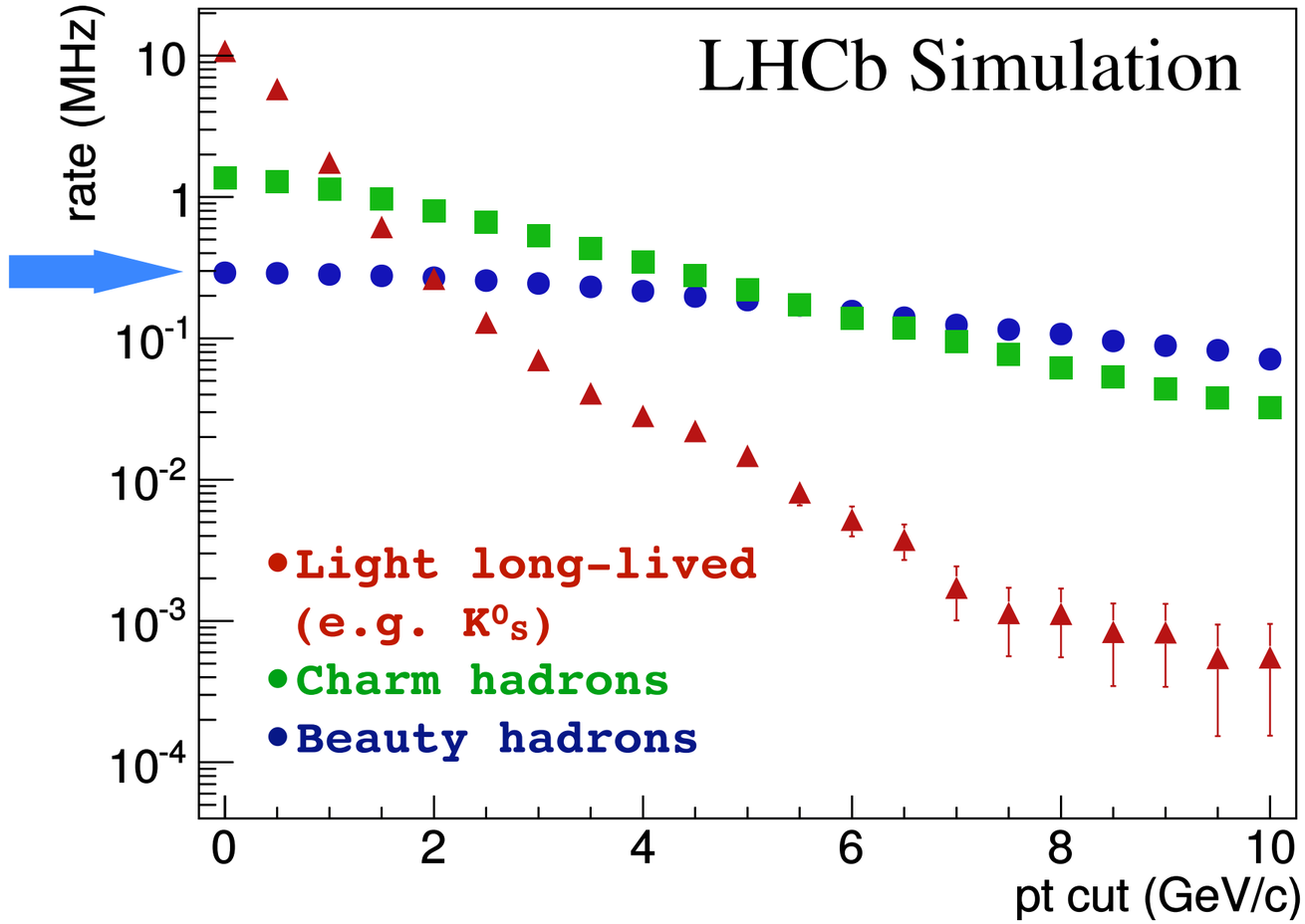


Let's come back to our fine print about interesting processes being a small subset of the total... less true in HL-LHC.

Track trigger @ HL-LHC

LHCb-PUB-2014-027

b-physics is just about OK



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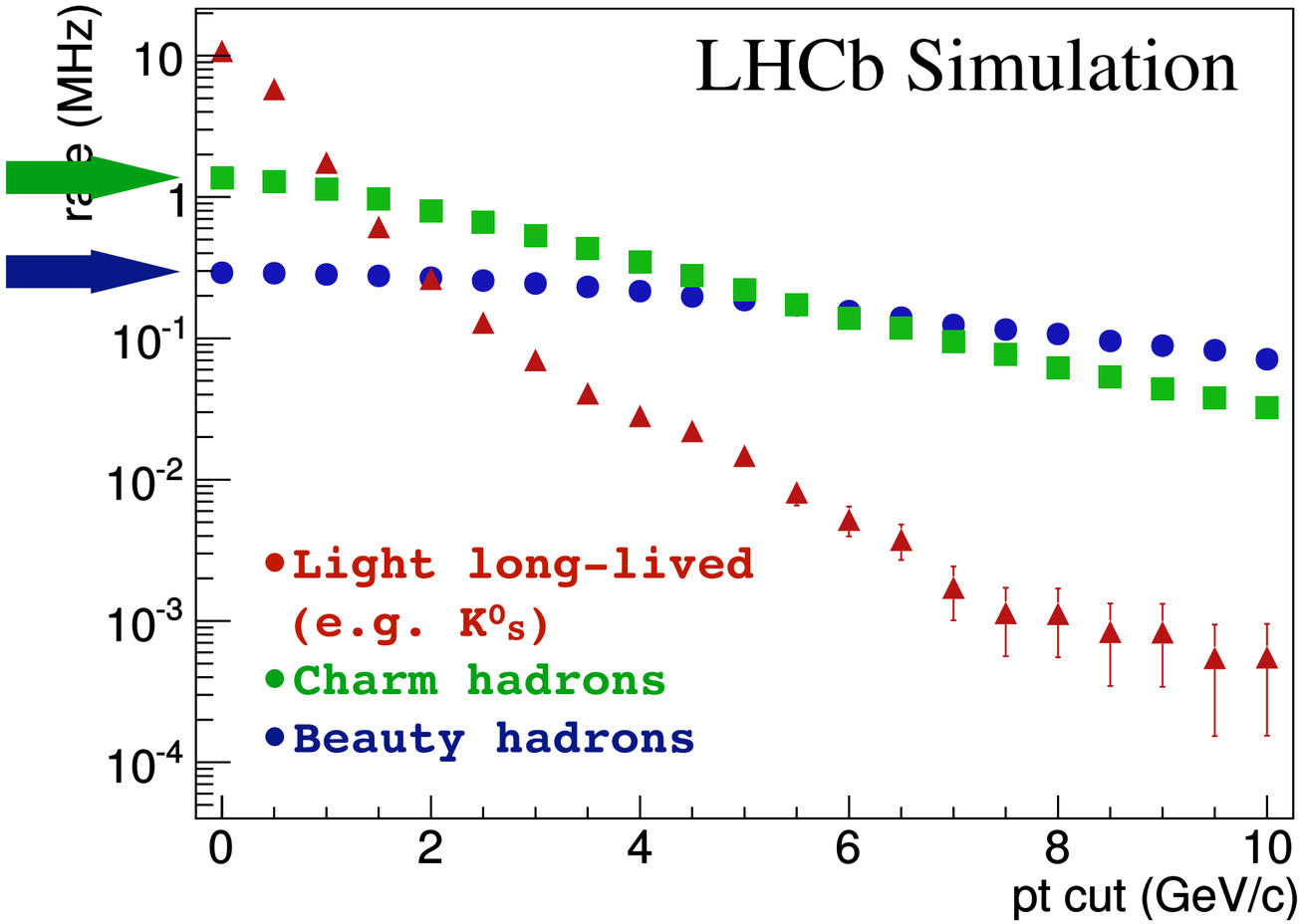
Track trigger @ HL-LHC

LHCb-PUB-2014-027

but charm...

b-physics is just about OK



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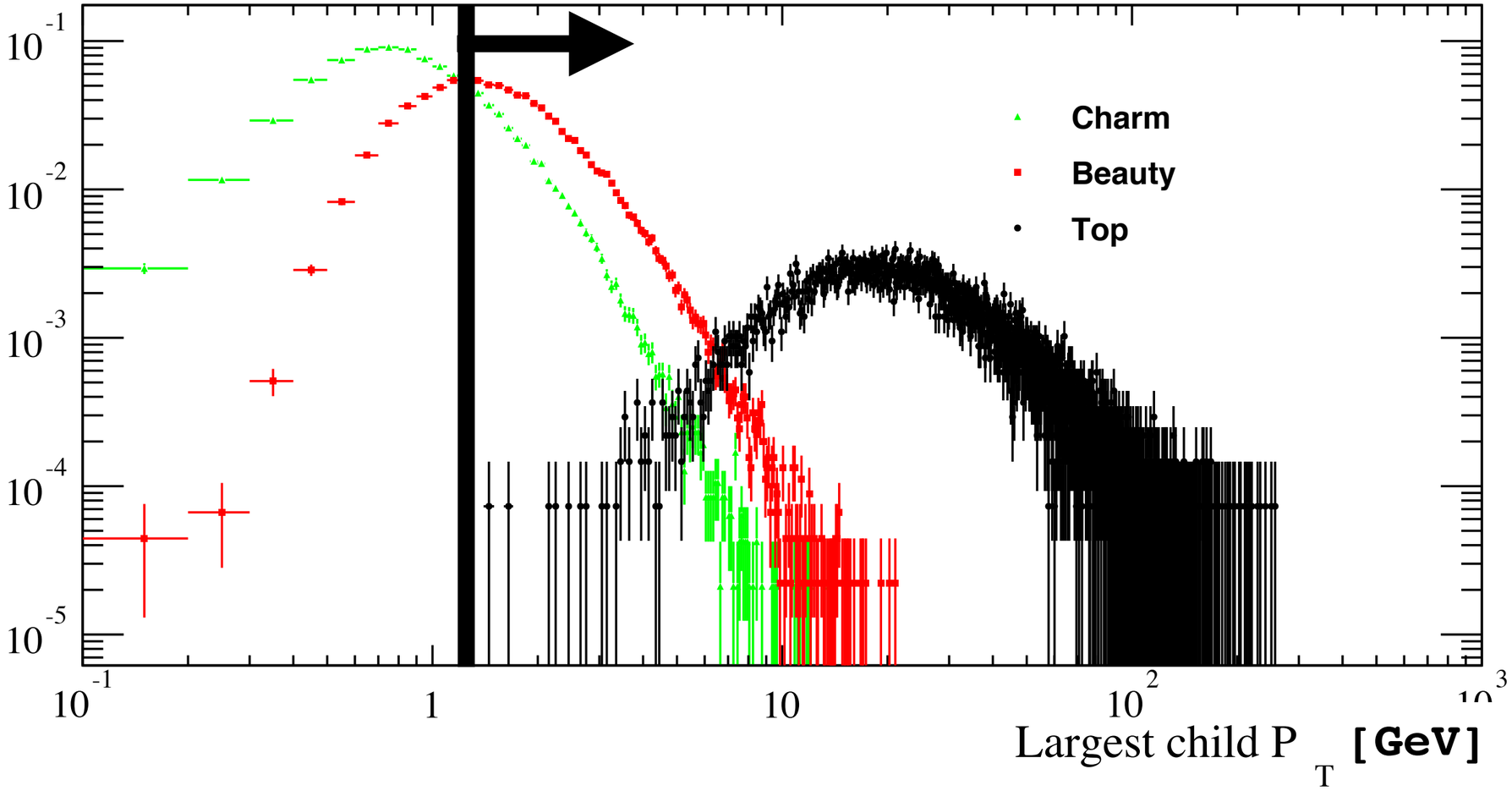
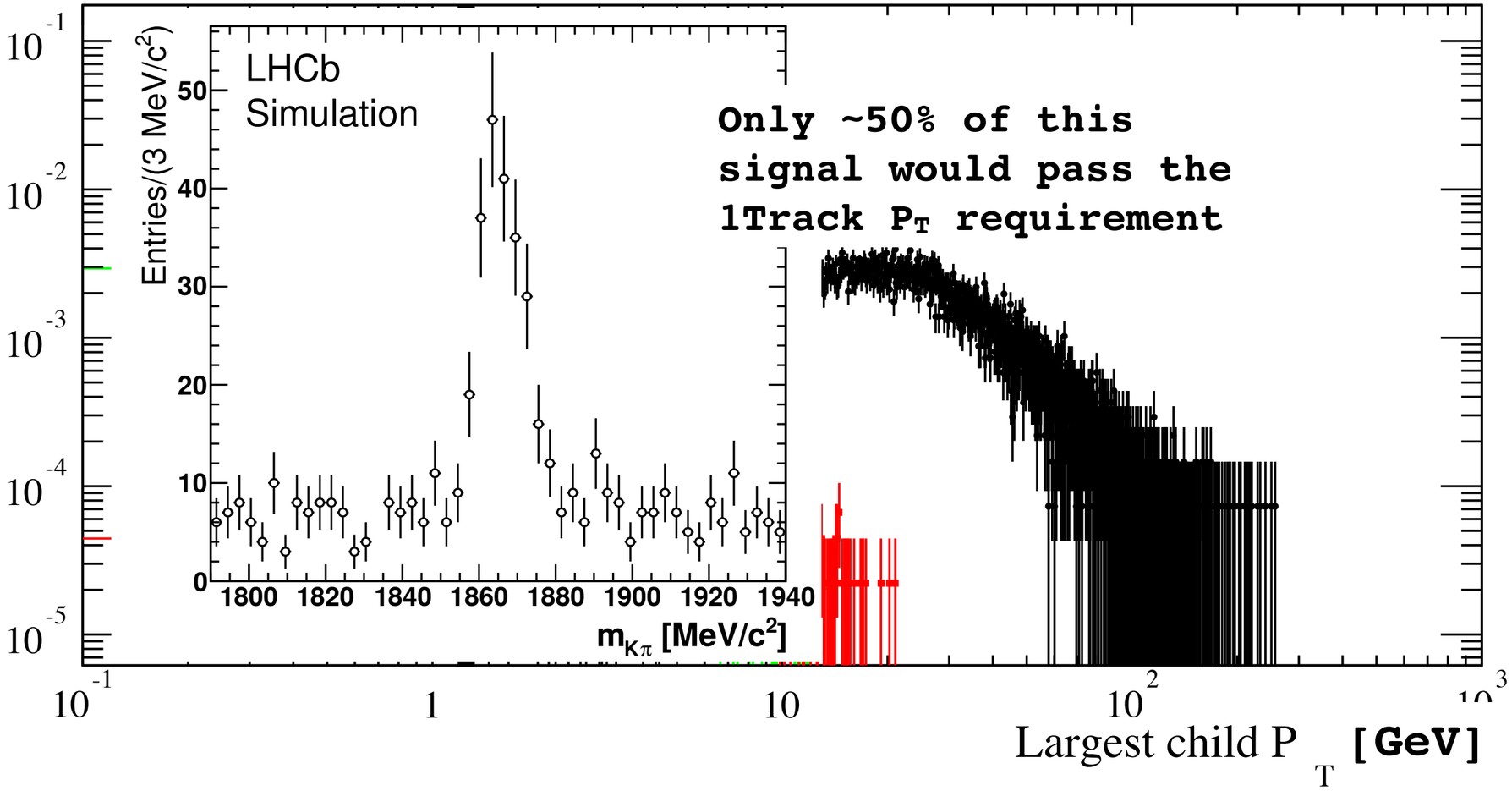
Track trigger @ HL-LHC



The problem is not beauty : you could get a ~20 rate reduction with good efficiency. The problem is that you are reducing this rate by killing charm independently of whether or not it would be useful later...

Track trigger @ HL-LHC



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Conclusions

Single track trigger works well for selecting beauty decays because

a) A beauty hadron is heavy enough that it almost always produces one high transverse momentum child.

b) At the LHCb pileup, bbar is still a small enough fraction of the overall event rate to allow a rate reduction this way.

However, in the upgrade we want to have efficient charm triggers, and since the track trigger works by killing charm, it is not suitable.

The track trigger will still survive as a seeding mechanism for rapid b-tagging : identify the high P_T track and then do track combinatorics only in a cone around it, thus greatly speeding up the building of bbar displaced vertex candidates.